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REPLY

TO THE

Montreal Harbour Engineer's Report

ON THE

ST. LAWRENCE BRIDGE

—AND—

MANUFACTURING SCHEME.

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F. FOSTER BATEMAN,

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3 Molsons Bank Chambers,

MONTREAL, 26th December, 1882.

To the Chairman and Members of the

"St. Lawrence Bridge and Manufacturing Scheme."

(SHEARER SCHEME.)

GENTLEMEN,

On Wednesday, the 20th instant, I was favoured with the report upon the above Scheme by Mr. John Kennedy, M. Inst. C. E., Chief Engineer of the Harbour Commission of Montreal; which I now, as your Engineer, propose to answer.

Before doing this, I should recommend to you the advisability of sending my answer to the Hon. the Minister of Public Works at Ottawa, of printing it in pamphlet form, and of having the substance of it published in the papers as soon as possible.

Mr. Kennedy's report is both able, exhaustive, and represents what must necessarily be the case, the natural feelings which would animate any person in his position, with such an important trust on his shoulders, when called upon to report on a scheme of such magnitude, as that which this session we are bringing before Parliament: provided, he wished to report as he should do, with a due regard to the interests of the public body which he represents.

Although I have already said that Mr. Kennedy's report is both able and exhaustive, I think that he has in some degree, taken upon himself more than was required of him; and that the conclusions he has arrived at, are in many instances incorrect; in others, that they touch more on the details of the scheme, without being of any important value in the general outline. Such details naturally belong to the after consideration of the scheme, should the charter be obtained; and would be adapted to meet all requirements, as shewn most advisable, after a much closer survey had been made, about the time when the works were going to be commenced. Such detailed survey would be far too expensive, and somewhat unnecessary for the purposes of a Parliamentary investigation.

It is further to be remembered that Mr. Kennedy has based his calculations upon my preliminary report to the Minister of Public Works, which although at the time perfectly correct, has been in some cases slightly modified and altered, to meet the further developements of the surveys, which have been conducted *very* fully, during the last twelve months. Also that the Bill which was left with the Government Officials, although shewing the general outline of the Act of Incorporation was only a draft Bill; and that owing to the postponement of the application to Parliament until the next session, neither the Bill nor the plans were necessarily those which would be presented this session. Little change, however, will be made in the plans; that which is made will affect only the details or extensions of the scheme, and not the general outline. The Bill should have some alterations and modifications inserted, but the outline and generalities of it will also remain the same.

I will pass over the commencement of the report until we arrive at Section 1, only remarking that the marked difference which is made between the words *feasibility* and *practicability*, (although meaning precisely the same), and the intention of using such difference, shows a desire to pass beyond the limits of instructions.

SECTION 1 OF MR. KENNEDY'S REPORT.

In this section of the report the following paragraph appears:—

"The Bill in Section 8 asks for power to construct and maintain locks, gates, sluices, basins, wharves, etc."

On this point I should strongly recommend that no claim to the rights of wharfage or the revenues therefrom derived should be made by your Company; but that any advantages we may create in this way by the building of our embankment should be handed over to the Harbour Commissioners.

The report then proceeds to question the harbour accommodation which your Company states it will afford to the Harbour Commissioners, at no cost to themselves. Taking the question according to the report, I would say that accommodation for, and in a harbour, is produced by nature or artificially, as the case may be. Such accommodation is dependent upon what is required from it, not upon what, in other cases, might be required from it. For instance, a broad deep bay in the centre of a highly productive country, at the head of ocean navigation, would be harbour accommodation of the very best kind. Such harbours can be seen at Rio Janeiro, Queenstown, and other places, and require little expense in utilizing them. On the other hand, a shallow bay or arm of the sea, under the same conditions, would require extensive and costly works to render them available for harbour accommodation; and such bays or arms of the sea may be seen in many places on the coast of Brazil, in the Rio de la Plata, and on the west coast of Africa.

In the case of rivers, such as deep, broad, sluggish, tidal streams, excellent accommodation is created, as in the case of Liverpool, London, Glasgow, and others; but more or less owing to the ebb and flow of the tide, costly works have to be erected, both for maintenance by dredging and convenience by wharfage; and in the above quoted cases, it is to be remarked, that *both* sides of the bays or rivers can be used.

In the case of Montreal, only *one* side of the river is at present available, and what your Company proposes doing is to artificially create a further available side by the embankment, to form a bay, to deepen the harbour where considered necessary, to decrease the present violent currents in the harbour, and by artificial means to give to the harbour of Montreal what at present it does not possess, two sides, and thereby to create accommodation which I maintain would be of the highest possible kind.

Most of these questions are admitted in the report, but the statements therein are qualified by questioning the advantages of such accommodation, and by stating the distances from the city. Supposing what you propose doing artificially had been done naturally, would it, or would it not, have been used before now for commercial purposes? I am convinced that if such were the case, the Harbour Commissioners *themselves* would have already built wharves there, without suggestion from any outside person.

The question, as introduced in the report, of cartage, is a small one, as railway communication will be in the immediate vicinity of any wharf that may be built, and that of crossing the canal is the same with regard to the present Mill Street wharf, or any future extensions, such as those proposed by Messrs. Bell, Newton and Fleming; and the fact that the Grand Trunk Railway and other lines now find it advisable to lay their rails on the present wharves is a strong argument against this objection.

Following the report, the question of the sluices and the adaptability of the wharfage in their proximity arises. I myself fail to understand how the calculations in regard to the velocity and discharges from the sluices are arrived at; but from the statements made in the report I should imagine that Mr. Kennedy has first divided the quantity discharged from all the sluices (as given in my report) by the number of the sluices, in order to find out what each sluice will discharge. That he has then taken the sectional area of the culvert or archway into which each sluice discharges, instead of the orifice in the sluice; for he says that each controlling sluice would discharge a stream of water 40 feet wide by 22 feet deep, and 20 feet wide by 22 feet deep in the case of each mill sluice; then, in order to find the speed, he appears to have divided the maximum discharge in each case by the sectional area of the stream which this would give, the stream so mentioned by him being the whole size of the culvert.

If my surmises are correct, this is a mode of arriving at the discharge of a sluice, or of verifying my calculations, which I am compelled to say I have never heard of before, and where, with the fall through the embankment, our head for water-power would be, if such a stream were possible, I am unable to say.

The sluices *will* be placed in the face of the embankment on the St. Lambert's side of it, and will have a head of water of more than five feet over the centre of each controlling sluice. These sluices will each be 40 feet long, with a five-foot opening, or 200 square feet in area; the mill sluices will be 20 feet in length, with whatever sized opening may be considered necessary. The water will have a velocity through the orifice or sluice due to the head upon it, and a discharge due to this velocity and the area of the sluice. At the immediate point of efflux from the mouth of the orifice or sluice, the velocity will be far greater than is claimed by Mr. Kennedy, but the sluice will discharge into still water in the culvert of the same level as that in the harbour, the culvert thereby forming a kind of tail-race about 150 feet long, and in the finished Parliamentary plans there is a further open tail-race shown which will be of greater width than the culverts.

The water will pass through the culvert and tail-race, with a gradually reducing speed, until it loses itself in the broad water of the harbour basin. As soon as it arrives in the water of the harbour, it will very rapidly lose its speed.

The discharge from all the sluices would gradually join together in the broad and deep water of the harbour, and would create an uniform velocity towards St. Mary's Current.

The difference of levels of water on each side of the embankment, although denied in the report, were marked upon the plan, shewing clearly the depth of the finished outlet of the sluices; but it has evidently been overlooked. But it must be remembered, as has been already stated, that the Parliamentary plans have been slightly modified, the maximum discharge at low water from all the sluices being now estimated at some 850 million cubic feet per hour, as against 935 million in my report to the Hon. the Minister of Public Works, and upon that report Mr. Kennedy has based his calculations.

With regard to the question of wharfage, why it should be necessary to berth vessels broadside on to the stated currents of from 3½ to 4½ miles per hour, I am unable to see, as I think much better arrangements could be made; but even supposing it were necessary to do so, the current mentioned, acting on the very small portion of each end of the vessel, berthed broadside on between the sluices, which would be exposed to such currents, would have little or no effect upon it.

Mr. Kennedy then says that a more favourable arrangement of sluices could doubtless be made, but my opinion is, that a more favourable arrangement of wharfage accommodation can be made, than that which he appears to think we contemplate. He further states that the discharge will have to be brought through a wharf, and will certainly create currents of a most objectionable kind and strength; it will not be brought through a wharf at all if such wharves are properly designed and constructed, and the report shews the current will not be more objectionable than those at present existing in different parts of the harbour; and I think in every way, even supposing there were no sluices to act on the shipping, the most economical (certainly as far as space is concerned) way of utilizing the embankment, would be by building wharves at right angles to it, and laying the vessels *end on* to the embankment. This is done at New York, under much less favourable circumstances than would be the case with your scheme.

It will therefore be evident that vessels coming up the harbour would, under such arrangements, run straight into their berths without any trouble; and even were the currents created by the discharge from the sluices, as great as stated (some 4 miles an hour) in the report, the vessels lying end on to the embankment, as they should do, would certainly not feel more inconvenience than they would do at Hochelaga.

In this manner at least double the number of vessels could be berthed in the same space between the sluices, to what could be done if laid broadside on or parallel to the embankment, and there would thus be no necessity for placing any vessel in front of the sluices.

Referring back to the remark, that a more favourable arrangement of sluices could be made, it is precisely for that reason that I have not shewn on the general plan the position of the mill sluices; and their position is one of those questions of detail to which I have already alluded.

I think I have now shewn how the currents from the sluices will not be brought through the wharves, or damage shipping interests in any way.

I further maintain that there will be no lowering of the water of the harbour, except at the top of St. Mary's Current, where there is now an upheaval of water; and at Sault Normand, where there is a fall of 2 feet 6 inches in a short distance. My calculations of the lowering of water at the top of St. Mary's Current, shew that it is due to the decrease of the current in the future, and this lowering will amount to about 6 inches, which is very nearly that of 8 inches stated in the report; but how the 8 inches have been arrived at so definitely for the general lowering of a harbour, now filled with water of a variety of levels, currents, and falls, I am unable to understand. But I am of opinion that it would be unwise for either the Harbour Engineer or myself to reveal the manner in which we have worked out our respective calculations at present.

SECTION 2.

The report denies that the velocity of the water in the "pocket" or "horse-shoe" is as great as I have stated. But Mr. Kennedy states that the only current approaching the velocity which I claim is at the Sault Normand; and there, he says, "where the water drops over the side of a shoal, and shows as a broken rapid at low stages of the river."

Now, in the harbour blue book, published in connection with the Bell, Newton and Fleming plans, at the end of the book, a paragraph, stated to emanate from Sir W. Logan, distinctly gives, as one of the reasons of the St. Mary's Current, the violence of the current of the Sault Normand. Now, if the Sault Normand is merely a rapid over a shoal of rocks at low water, how could it possibly have any marked effect upon such a mass of water as passes hourly through St. Mary's Channel? It is further stated that after the embankment is built, etc., the site of the sault will be occupied by the larger and slower flow from the sluices, but this is termed as merely incidental, and not a point of advantage in itself, although the currents from the sluices have already been criticized, as being of a most objectionable kind and strength.

It is precisely because these currents at the upper end of the harbour will be so much slower in the future, that you will be able to maintain the harbour at its present level; and as the discharge through the narrow orifice at St. Mary's Channel requires a certain velocity to pass the now full volume of the St. Lawrence, which velocity, according to Sir W. Logan and myself, is created greatly by the force of the upper current such as the Sault Normand, the lesser speed in the future, not having the same force, will be unable to pass through St. Mary's Channel the same quantity of water in the same time, but only about two-thirds of it, or rather less. This is what in the future it is proposed to supply to the harbour, and it is for this reason that the harbour will be kept at its present level.

This is one of the main features of the scheme, and cannot therefore be called either incidental or of no great advantage.

Without going into what can or cannot be proved, either by going up through the channel near Sault Normand or Sous-le-Mont, or by watching the steamer passing up, and by comparing the velocities in St. Mary's Current with what you observe in the above mentioned channel, "pocket" or "horse-shoe," it will be easily ascertained that at one point between Sous-le-Mont and the end of Moffatt's Island wharf the current must be considerably greater than St. Mary's, and it is further a fact that without greatly increasing the current in the vicinity of this point over 6½ miles per hour, which the report asserts it to be, the whole volume of the river St. Lawrence could not be passed through such a channel into the harbour, as is now the case.

SECTION 3.

Mr. Kennedy does not appear to consider the cost of removing detritus brought down each year as serious, although he admits that it is felt in the cost of dredging; but I am of opinion, supposing our works are not made, that when all works are finished in connection with deep channels and deepening the harbour, he will find that as in the case of all navigable rivers, the cost of clearing the detritus brought down by the scour from gravel or boulders, will be a serious item in the future expenses of the Harbour Commissioners; and if it is remembered that every dollar annually expended, represents a certain capital which at 5 per cent in 14 years doubles itself, it becomes a far more serious matter than seems to be admitted in the report.

It is then stated in the report as follow: "As to the deposit from local causes, by which I understand sewage deposit, rubbish from ships, etc., I cannot see how the lesser scour which will be obtained from the sluices would clear this out when the winter and spring flood of the river fail to do so. On the contrary, it seems to me that the reduced current especially during winter would allow of the deposit of some of the sewage matter now swept away."

With the above quotation my opinion is entirely at variance. The Harbour of Montreal, is as I have before stated, and which the report in many places admits, filled with different currents, different obstructions, and the contour of the sides is in every case irregular. Now, all these phenomena are reasons for backwater and eddies, and for the consequent deposit of sewage matter. Whatever may be the future result, that we can do away altogether with this I consider improbable; but the water as now discharged into the harbour is delivered spasmodically, owing to the irregularity of the bed over which it has to pass, and it proceeds with different velocities derived from local and other causes, increased in some cases, decreased in others, until it discharges into the broad river below the harbour. In our case we propose an uniform and regulated discharge into the harbour; regulated by the area of intake, as also by the area of eflux; with a velocity due to whatever head is created near our embankment, and although eddies and backwater will not probably be absolutely done away with, they will certainly be ameliorated, and the sewage will pass down more slowly, but more regularly.

SECTION 4.

This section passes on to state with regard to St. Mary's Current as follows:—

"At low water I find the highest mean rate taken with a loaded rod, of 20 feet depth, and showing fairly what a ship has to stem, to be about 4¾ miles at the head of St. Helen's Island, 6 miles at the Canadian Rubber Factory, Papineau Square, and 7 miles at the middle of Ile Ronde, where it attains the highest speed."

With regard to the foregoing, I am of opinion that a loaded rod by no means shows fairly what a ship has to stem; and as the majority of vessels now coming to Montreal do not average more than from 20 to 22 feet draught, I cannot see how the keel of a vessel will represent the point of greatest resistance to the water. A loaded rod of 12 feet depth would be much nearer the mark, but I am of opinion that loaded rods or submerged floats by no means show the true velocities, as the different currents above, acting upon the gearing, increase or decrease the speed of the float, thereby giving an erroneous velocity for the stream.

I myself took the velocity of the stream with surface floats and a current meter. On the surface the current meter and floats exactly agreed, but nine feet below the surface the velocity increased from about 7½ to about 9 miles per hour. This, in my opinion, is due to the narrowing of St. Mary's Channel, the piling up of water behind it, and the consequent undercurrents created in order to pass the great body of the water. No doubt 20 feet below the surface the currents would be greatly decreased, owing to the near approach to the bed of the river and the consequent loss of velocity by friction on the bottom and sides.

The report goes on to say:—"At ordinary high water of 22 feet on the sill, the rate at Ile Ronde rises to 7½ miles, and at other places in proportion." Further on it states: "With the embankment built and the discharge through the sluices, that the speed 'at *low water*' would be reduced to about 5½ miles an hour, and at *high water* it would be reduced to 4¾ miles an hour." I fail to see why high water in one case should give an increased velocity, and in the other case for high water a decreased velocity, and for low water an increased velocity in St. Mary's Current. It appears to me that these two statements contradict each other.

Mr. Kennedy admits that the decrease in the current of St. Mary's would be felt as a great relief, but questions the money value of it. Relief in this case means a saving of time, fuel and labour, and each of these represent money. Again comes in the question of every dollar annually spent representing capital.

Further, the report states that four screw-tugs are kept in use, and a chain-tug was built expressly for St. Mary's Current, and although it has never been used, there must have been some reason for building it. Possibly with the reduced current the four tugs would not be necessary; certainly they would use less fuel.

It is further stated:—"With these facts in mind as regards the whole current, it would seem that taking away about one-third of its rate can hardly be of such practical value as to be much felt."

First of all, I question these facts, both with regard to the velocity Mr. Kennedy states there is, and will be, in the St. Mary's Current, and also as to the amount the current will be reduced; and I think I have shewn, by using his own arguments, that the reduction of the current *will* be of great practical value. At any rate, I question whether ship-owners would agree with him.

Before leaving this section of the report, I should like to draw attention to a sentence in it, as follows:—"In every case the speed falls off rapidly towards the shores, and vessels according to their draft can find water at one-fourth to one-third less speed of current." According to my limited experience of nautical matters, I should imagine that any ship-master or pilot in charge of a vessel of considerable size would always choose the deepest portion of the channel for entering a port, which in this case would be the centre of St. Mary's Current; ordinary prudence would lead him to do so in so confined a channel, even though he would have to encounter the strongest part of the current; for should he hug the shore to avoid the strength of the current, should anything unforseen occur, especially in the case of a sailing vessel being towed; should such vessels not answer their helms well; and in the case of a vessel in tow of a tug, should she take a broad sheer inshore, and part the hawser, they would be swept ashore in a very short time.

SECTION 5.

Mr. Kennedy finds that the fall from the foot of Lachine Canal to the foot of St. Mary's Current is from 22 to 24 inches. In some cases he is no doubt right; so much the better for my arguments, and I will shew how:—

Admitted, as every reasonable man must admit, that the water of the St. Lawrence will follow the laws of nature, from which laws, by multitudinous experiments have been evolved certain correct formulas for hydraulics.

With a 2 feet 3 inches head from Lachine Canal to the foot of St. Mary's Current, only between 700 and 800 million cubic feet of water per hour could be passed; but actually nearly 1,300 million are being passed. But by taking the fall from above Sous-le-Mont to the foot of St. Mary's Current, which is a distance rather less than that above mentioned, the fall is about 4 feet 9 inches, and gives by calculation a discharge through St.

Mary's Current of nearly 1,300 million cubic feet per hour, agreeing thereby with actual experiment. With only 24 inches fall from Lachine Canal, it is obvious that the discharge would be still less through St. Mary's Current (if such discharge were due merely to that head of water), and it proves that there is a considerable further fall or head of water in the vicinity of Sous-le-Mont, which we intend to utilize for giving a portion of the head necessary for the discharge through our sluices; and as such discharge through the sluices will amount to between 800 and 900 million cubic feet per hour, we must, as the distance from our embankment to the lower end of St. Mary's Current is a little less than that from the Lachine Canal lock, create by the discharge which will come through our sluices a head of water at the upper end of the harbour sufficient to give a velocity for discharging between 800 and 900 million cubic feet per hour through the narrow part of St. Mary's Current; and the head must be more than 2 feet three inches, because a 2 feet 3 inches fall from Lachine Canal will only pass some 800 million cubic feet per hour, and we must in a less distance have sufficient head to pass between 800 and 900 million cubic feet per hour through the same channel.

From the above I think it is shewn that if the fall from Lachine Canal to the lower end of St. Mary's current, is only 24 inches at the present time, and *we must* have a head of 2 feet three inches, to pass the discharge which will come from the sluices through the same waterway, in some part *we must* raise the water of the harbour, and not lower it.

I further question in every way the velocity of 4 miles per hour opposite the Hudon Cotton Mills.

The statement that there is a stationary wave is proved incorrect by the fact that it varies from 1½ to 3 inches.

Why only 90 per cent of my estimated discharge through the sluices should be taken, I am unable to understand, as my calculations for the discharge are based on the theoretical discharge, due to the head upon the sluices; and only 86 per cent of such theoretical discharge is usually taken as being effective; therefore my estimate is only 86 per cent of a theoretical discharge.

SECTION 6.

This part of the report I agree with in the main, but I think the ice jam at St. Mary's Current is far underrated, as also the advantage to be gained by the city by doing away with it.

SECTION 7.

Section 7, I naturally agree with.

SECTION 8.

The reports admits the excellence of the highway and footpath, but qualifies this by remarking upon the disadvantages which must necessarily accrue to any bridge for such purposes over the River St. Lawrence. But considering that there is now no highway or footpath across the river, nor present probability of one being made, it seems to be going rather out of the way to remark upon the disadvantages.

SECTION 9.

With regard to the water power at the embankment, Mr. Kennedy's main objections are the question of ice. Now both his objections against, and my argument in favour of, the possible result; must by their nature be hypothetical, and this I think he does allow.

My opinion is, that after the alteration of the current in the south channel, the clearing of the channel, the considerable depth of the sluices on the St. Lambert's side below the surface, when the river is highest, and the head that will then be upon them, they will answer the purposes for which they are intended.

With regard to the drowning out of the water power, this would not be the case; for if so, Mr. Kennedy's arguments in other portions of his report must fall to the ground; such as the flooding of La Prairie and the rise of water on the St. Lambert's side of the embankment, and also the lowering of the water in the harbour. But there will always be a head of water on the upper side of the embankment, no matter what happens, and arrangements could be made to always utilize this head. The back water in the River St. Lawrence is not in the true meaning of the word backwater at all in my opinion. But it is I think, the piling up of the water of the river, caused by obstructions lower down, the smaller water way, the altered velocities, and the double wetted perimeter; but it always has a certain velocity, except in certain places, and a certain movement forward. The velocity may be sometimes slower, sometimes more rapid, but the water is never absolutely at rest.

Although the embankment will be parallel to the shore of Montreal, as Mr. Kennedy says, the conditions of the river if the embankment be built, will by no means be to that embankment, what the conditions of the river now are to the shore of Montreal.

A glance at the map (I quite agree with Mr. Kennedy) *reveals* the causes which make the main water of the St. Lawrence flow towards the Montreal shore, but I doubt much whether we should agree as to *why* it does so.

The reason why the ice is thrown on the shore of Montreal, and why the great ice shoves in the harbour occur, as at present, is because by local causes the current is thrown across the narrow ledges of rock, through the "pocket," carrying along quantities of floating ice and frazil, which is deposited in the harbour. As soon as too great an amount to pass through St. Mary's Current is accumulated, the current acting almost at right angles to the shore of Montreal throws the ice on to the revetment wall, and creates the shoves which now occur.

By walking on the ice in the winter, or rather tumbling over it, you will find it in every portion of the harbour piled up in every possibly conceivable shape; you will be able to clearly trace the shoves, and you will find that the lines of these shoves are below the site of our proposed embankment, and running about parallel to it.

I maintain that when our embankment is built, Moffatt's Island wharf and all obstructions in, or on the sides of the South Channel are removed, and every facility given for a clear water-way; the water will pass straight forward down the South Channel. At the present moment, were our embankment built, the currents in the river remaining the same, neither those currents nor the ice would strike the embankment in the same way as they strike the shore of Montreal, and I hold in no two cases could the present and future conditions of the river be more dissimilar.

Mr. Kennedy also states in this section of his report that—"as the same features do to each other and to the shore opposite the central part of the city; and plainly the causes which now work to heap up mounds of ice on the city front would hereafter act upon the dam." But in page 3 of his report he says:—"The building of the bridge is a simple matter, and presents no difficulties. Neither is there anything in the main features of the design which need make it difficult to secure the details from damage by the action of the ice." Surely this is somewhat of a contradiction.

I am of opinion that the shallow ridge of rocks, and the rapid currents near Sous-le-Mont and at the toe of the boot of Moffatt's Island wharf, which deflects the current towards Montreal, are some of the reasons for the creation of a large portion of the frazil in the harbour of Montreal.

It is natural that in the swifter part of St. Mary's Current frazil should be found, as also at Sous-le-Mont.

Certainly, mills and factories do use water-power, and successfully in this country, even with the low water-fall which Mr. Kennedy refers to. I deny the truth of this very low water-fall during the summer months, as my calculations are based upon data taken in December, 1881, when the river was never known to be lower.

Mr. Kennedy further proceeds to state:—"Lifts and warehouses, etc., are mentioned as cases in which a summer power only is required, etc., would not probably utilize the power of a single sluice of the size proposed." This is *entirely* wrong,

Are we to suppose that the commerce of Montreal is to remain in a state of stagnation, and never increase?

Are the different railways, etc., now being built mythical, and will they develop the resources of Canada?

Montreal is the head of ocean navigation, the biggest city in the Dominion. Will it be wise, for want of a little foresight and energy, to permit such an opportunity of providing for the necessities of the future to slip by?

OTHER EFFECTS OF THE SCHEME.

Before entering upon this part of the Report, I am compelled to inform you of certain facts which came to my knowledge during the Surveys which I personally conducted last year.

I am compellnd to do this, as in this the most able and exhaustive portion of the Report, different dimensions and measurements of the River St. Lawrence are greatly referred to, and calculations based upon them.

The result of my Surveys shows that there are grave discrepancies in the public Plan and Survey of the Harbour of Montreal; and as these discrepancies touch greatly upon the calculations arrived at by the Harbour Engineer, I am obliged to take cognizance of the fact.

My Surveys do not agree with the public plan of the Harbour of Montreal, but they do agree, except on the South side, with that of Bell, Newton and Fleming; and I find in their Report that they also detected errors.

My Survey disagrees with the Harbour Plan in the position of Ile Verte, St. Helen's Island, and Ile Ronde, and also on the South shore, and is remarkable in this that I find the width of St. Mary's Current considerably less, and the South Channel greater than Mr. Kennedy states (2,700 feet).

The position of the above-mentioned Islands in the Bell, Newton and Fleming plans agree with mine.

FLOODS AND ICE SHOVES.

Mr. Kennedy goes on to say: "By far the greatest question raised by the Scheme is that of its probable effect upon the height of the River, at the time of the great ice shoves. Sir W. Logan has vividly described, and clearly discussed, the causes of these grand phenomena of the St. Lawrence"—and it is from a portion of the following extract in this Report of Sir W. Logan's, that I propose partly to argue your case upon. Sir W. Logan says: "There is no place on the St. Lawrence where all the phenomena of the taking, packing and shoving of ice, are so grandly displayed as in the neighbourhood of Montreal, the violence of the Current here is so great, etc." Further he says: "By the time the ice has become stationary at the foot of St. Mary's Current, the waters of the St. Lawrence have usually risen several feet in the Harbour of Montreal, and as the space through which this Current flows affords a deep and narrow passage, for nearly the whole body of the river, it may well be imagined that when the packing here begins the inundation rapidly increases. The confined nature of this part of the Channel affords a more ready resistance to the progress of the ice, while the violence of the Current brings such an abundant supply and packs it with so much force, that the river dammed up by the barrier which in many places reaches to the bottom, attains in the Harbour a height usually 20, and sometimes 25 feet above summer level."

Before using the above quotation, I must ask you to follow me through some portion of the remarks in the report. Passing over the remarks on La Prairie Basin and Victoria Bridge for the present, I come to the question of the breadth of St. Mary's Channel; it is stated to be 1,900 feet. I suppose this is at the narrowest point, and at low water. It should certainly be taken at the narrowest point for the question we are now touching upon, Now, I maintain it is not 1,900 feet, but only about 1,400 feet. The Report states the South Channel to be 2,700 feet. I maintain it is between 2,800 and 2,900 feet wide, but when the works are completed, even taking the present low water and present condition of the river as the basis of calculation, this Channel would be instead of 2,700, 3,100 feet wide.

Many of Mr. Kennedy's further measurements I do not agree with, and I will ask you to pass on to the next paragraph of his Report.

Now, going back to Sir W. Logan's statement, I find that *he* lays great stress upon the confined nature of St. Mary's Current, upon the violence of the currents of the Harbour of Montreal, and upon the packing of ice from these two causes; and he appears to put little value upon the depth of the Channel, but, to look upon it, considering its confined nature, to be rather detrimental than otherwise.

The action of ice must necessarily be a question upon which nobody can form any *exact* theory; but, to form a theory at all, you must bring the question down to units.

In the case of St. Mary's Channel and the South Channel, I propose to do this. (See tabulated form appended.)

Mr. Kennedy is not quite in accord with Sir W. Logan, but no doubt his later experience accounts for this.

Sir W. Logan says: "The confined nature of this part of the Channel (St Mary's Current) affords a more ready resistance to the progress of ice, while the violence of the Current brings such an abundant supply, and packs it with so much force, that the river dammed up by the barrier, which in many places reaches to the bottom, etc." Mr. Kennedy states: "At Ile Ronde, too, where the St. Mary's Current is narrowed, the Island is submerged at high water, and the loss of breadth is made up by the enlargement and deepening of the Channel between Ile Ronde and St. Helen's Island." A more absolute maldistribution of argument, I think, never came under my observation before.

Why should we not be allowed to use shallow water, if Mr. Kennedy is allowed to use it, as must be the case in the submerging of Isle Ronde? and why cannot we calculate upon rises in the south channel, as well as Mr. Kennedy does in St. Mary's Current? (which is the interpretation I give to "enlargement and deepening" in his report.)

From the above, I think I have shewn that the depth of the water, is by no means so important as the floating surface of it.

Ice is a floating body, and it does not matter under what conditions, it must follow the rules of such bodies; and a channel with a floating surface double that of another, must pass the same quantity in half the time. All floating bodies are capable of being directed in their progress, and I maintain that what we propose in the South Channel will be able to pass floating masses of ice at the lowest water, in less than half the time we could pass them in St. Mary's Current.

I would further point out to you, again, the quotation from Sir W. Logan, that the harbbour of Montreal is filled, and St. Mary's Current jammed, far more speedily, owing to the violent currents, than Mr. Kennedy seems to think; and, with the reduced distance, and more uniform current, which we propose in the South Channel, such will not be the case.

The strongest proof of this is, what has just been handed to me by one of my assistants, living and employed on the St. Lamberts side of the river in watching the take of the ice, that the South Channel is now, 25th December, 1882, entirely open from Moffatt's Island Wharf nearly down to Longueuil Wharf; whereas, from other data given to me, St. Mary's Current is already jammed; then, as proofs of what I have already said, and will say further on, when the ice is released from above Moffatt's Island, my observations shew that it was swept into the harbour more rapidly, thereby filling the harbour with accumulated ice,

I further deny, from personal observation, that ice *passes freely* over the obstructions in the river such as wharves.

Following on from the above, let us take a paragraph in Mr. Kennedy's Report; he takes fifteen feet as being the rise above low water mark at Montreal in the winter; he then takes 65 feet as being the greatest depth of St. Mary's Current (I suppose in Winter.)

Is St. Mary's Current 50 feet deep in any part at low water? and has it an *average* depth of 35 feet? It had not in December, 1881, the greatest depth at lowest water being

38 feet in the narrowest part. If it has been lowered 12 feet since then, the velocity of the current must be considerably increased, and the lowering of the harbour must have already commenced.

But I think if we were to take 50 feet as the winter depth, and 30 feet as the average (Mr. Kennedy's rise being 15 feet at Montreal in the winter), we shall be nearer the correct thing; and if we take St. Mary's Current (owing to the rise of water) to be somewhat wider than 1,400 feet, say 1,500 feet, with an average depth of 30 feet (instead of 35 feet, as per Mr. Kennedy), we shall have a waterway of 45,000 square feet area, instead of 73,000 square feet, as per Mr. Kennedy.

With a 10-foot rise in winter, as common to the upper portion of the river (as per Mr. Kennedy), the average depth in the South Channel in its present state (I suppose at the site of our bridge) of 15 feet would, I think, be about correct; but taking the rise of 10 feet in the river, the breadth would be over 3,000 feet, and would give us an area of 45,000 square feet, as against 40,000 square feet (as per Mr. Kennedy).

The two channels together would thus give us an area of 90,000 square feet, as against 113,000 square feet (as per Mr. Kennedy).

With a rise of 10 feet at Victoria Bridge, according to Mr. Kennedy, the sectional area is about the same, but he gives as depths, with a rise of 10 feet, only two, viz., 14 and 28 feet. Taking his breadth at Victoria Bridge as 6,570 feet (which is wrong), and an average depth of 21 feet, we have a sectional area of 127,970 square feet; whereas the sectional area of the whole river of 4,600 feet by 24½ feet, his average depth, taking all the channels, only gives 110,000 square feet. These statements do not agree, and are certainly not quite correct.

Mr. Kennedy then proceeds to discuss the currents or motive power in ice-shoves, and although, as I have already shown, I do not agree with him in his velocities at low water, I agree with him as to the currents being diverted and changed during winter.

Mr. Kennedy then shows that the ice blocks, owing to Victoria Bridge, are only 240 to 330 feet broad. He then says:—"The gorging of the river and the formation of ice-dams are, however, not due to the size of the masses, but to their quantity, for only such blocks as can be rolled under the stationary ice are effective in choking up the water channel." At the present time few sheets of ice are passed down the South Channel, but nearly the whole of the ice is carried into the harbour basin by the violent currents, as already shown; and, as explained by Sir W. Logan, the confined nature of St. Mary's Current is an incentive to the jamming of ice.

This must naturally be so, because of the violent currents, and the entrance to the South Channel being obstructed by Moffatt's Island Wharf.

This channel is filled with different impedimenta, and although at *very* high water it may pass off some small portion of the floating ice, the natural direction of floating bodies is with the strong currents. When this is altered, the South Channel deepened and widened, and the rise due to that volume of the St. Lawrence which will in future pass down the South Channel, is taken into consideration, I maintain that the risk of jams will not be great.

But taking again Mr. Kennedy's report, I find that he says "that the formation of ice dams is not due to the sizes of the floating sheets of ice, but to the blocks that can be rolled under the stationary ice."

Now, with extra velocity, clearing away all obstructions, deepening, widening, and the rise due to the extra volume of water down the South Channel, I think the ice will not become stationary sooner than in St. Mary's Current, and not as soon. After having become stationary it will take longer to fill up, for the following reasons: The South Channel is in width at lowest water nearly 2¼ times that of the St. Mary's Channel, and can pass down double the floating blocks of ice in one layer, supposing it is sufficiently deep.

For every rise of one foot of water in the South Channel, St. Mary's Current must rise 2 feet for increased area, and so on every foot until it reaches its maximum.

It will be plain from this that by continually multiplying the increased sectional area of St. Mary's Channel by 2, we shall soon get in the South Channel an equal sectional area to that which the two channels give now; and we shall also have the sluices in the embankment to help us. I append a tabulated form of the above.

I find from Mr. Kennedy's history of floods, that after 1860 they appear to be due to the jam of ice at Boucherville; before that date they appear to have occurred at the site of Victoria Bridge, and higher up the river. It would therefore appear that Victoria Bridge has had much to do with freeing the river from jams above the city. Victoria Bridge somewhat narrowed the river, but did not raise the water higher than that due to the obstruction of the piers and the length of the abutments. We propose to widen the river at the site of our Bridge, raise the water, and give a fairly uniform velocity. Whereever, after careful examination of the shores, we find low portions likely to be flooded on account of the extra rise which we should create in the South Channel, levees of a height of 5 feet above the maximum height the St. Lawrence will be raised in the South Channel by our works will be built; thereby making a shore level equivalent to the rise we shall create.

I cannot understand the following sentence in Mr. Kennedy's report:—"In investigating the practical consequences of ice jams, as distinct from their causes, it appears at once that it is only the floods which accompany the jams that are of serious importance. The movements of the ice itself for the most part occur within well-known limits, and are easily guarded against, but the floods extend over great and indefinite areas, and work serious damage." Mr. Kennedy is wrong. Floods do not accompany the ice jams, but are an after consequence, and the floods themselves dispose of the jams; therefore, the broader the channel used for passing ice, the better. He seems in this case to contradict himself, as by his own shewing the movements of ice do not occur within well-known limits; at least, if they do, the limits must be enormously large.

He further states the channels of the river are already too small. This by the nature of things cannot be so; but they are no doubt in many cases badly adapted for the passing of ice, as in the case of the violent currents in the harbour, and the confined nature of St. Mary's Current, as shewn by Sir W. Logan.

What we propose doing is to give a short, straight channel, over double the width of St. Mary's, which will have uniform velocities, and which, I maintain, is better adapted for the passing of ice, and will do it quicker than the longer and more circuitous channel, with spasmodic currents, through the harbour and St. Mary's Current.

I have already gone into the relative sizes of these two channels as at present, at high water, and it is not necessary again to touch upon them.

Mr. Kennedy then passes on to say that it is not a question of the capacity of one channel, but of the two channels; but he omits to define what the capacity of a channel means.

It means what water it will pass, and this is due to the sectional area of the channel and its velocity.

It will be evident that a channel without any obstructions, and with an uniform velocity, will do its work far more easily than one with spasmodic and different currents, and with obstructions due to the irregularities of the shores and bottom.

I therefore maintain that the South Channel will, with what we propose as its future conditions, be able to do the work much better than the present arrangement, and will have a sufficient capacity.

It is then said in the report:—"These and other instances which might be quoted all go to show that the channels of the river are already too small, that they are liable to be choked with ice in any winter, and the experiences of the past to be repeated" It is further stated:—"Whatever increase of capacity the St. Lambert Channel can have given it by the highest permissible rise of water, it may have and does have now." I do not agree with this statement. The highest permissible rise is the height for which we make provision in the future, and works of safety will, as already stated, be made for the maximum rise which we create.

Mr. Kennedy then goes on to state:—"That we propose doing nothing of importance in the South Channel, except the deepening of a portion for the boat channel."

This is *entirely* incorrect. We do *everything* of importance; we lower the bottom some two feet; we do away with all present obstructions; we give a free intake; we widen the channel by straightening the sides; we build our embankments with a view to guiding the ice as fairly as possible towards the narrow portion of the channel; and we widen the area of eflux at the point of discharge from the South Channel. Is all this unimportant?

The sectional area of the piers of our proposed bridge will not be one-third that of the proposed boat channel.

The report next states:—"The water is intended to be raised high enough to force itself through, but no elevation of the surface within the safe flood level, can give this channel alone a sectional area equal to that of both channels." As I have before shewn, the elevation of the surface of the water in the South Channel can be guarded against by works of safety, and, by Mr. Kennedy's own shewing, the flood rise of water will be only increased by the amount that we raise the surface, in order to pass the volume of water which has to be passed.

We then come to the following statement:—But it is not a mere question of sectional area, for manifestly the great depth of the central part of St. Mary's current, is a safeguard against it being choked by the ice, while a shallow one is especially liable. If, however, a pack does take place in the deep channel of sufficient extent to retard the water and cause it to rise farther up, the St. Lambert Channel comes in to assist, and the two together pass the water with ease"—and I may here say that in many places in Mr. Kennedy's report he states that *it is* a question of sectional area, and he apparently does not agree with Sir W. Logan in this.

I should like to ask now a practical question, although there may be exceptional cases in connection with the formation of ice, which will alter this: whether a deep narrow channel, or a broad, fairly deep one, would be best for passing floating bodies?

For every rise of one foot it must always be remembered, that for the increased sectional area of St. Mary's Current for that one foot, the one foot rise in the South Channel gives more than double.

Mr. Kennedy must, if the latter part of the above quoted clause be correct, allow that the South Channel never jams even now, because, if with its extreme shallowness it did do so, it could not help the St. Mary's Current, and he allows "that if a jam does take place sufficient to retard the water in the St. Mary's Current, the St. Lambert Channel comes in to assist it, and the two together pass the water with ease;" but Sir W. Logan says that St. Mary's Current in many places sometimes jams down to the bottom, thereby shewing that the South Channel, both by Sir W. Logan and Mr. Kennedy, has to do at present a great portion of the work, which we propose it should do in the future, and with the rise, deepening, etc., which we propose, in the future it will be capable of doing all the work.

Mr. Kennedy says "the bottom of St. Lambert Channel, even when cleared out, will be higher than the bottom of the river in its vicinity," and then goes on to say it will be five feet higher. The South Channel has many points in it; to which point does he refer? I think this need not be touched upon, as he is wrong in his supposition, they are certainly not shewn in my plans.

Mr. Kennedy then goes in for a scheme of his own. He proposes sundry things which he says are practically the same as our Scheme. I deny the truth of that. They are neither the same as the present or future conditions of the River where we propose to place our embankment. Why take a supposed position in a river, utterly different in currents, in depths, velocities, area, contour of the sides, and phenomena above and below; and suggest it is the same as something situated in an entirely different spot, and with entirely different conditions.

I believe I said in my Report to the Honorable the Minister of Public Works, that the right fall to be taken for the Harbour should be 4 feet 6 inches, instead of 2 feet 3 inches, as now taken from the sill of Lachine Canal Lock; and taking this fall of 2 feet 3 inches shows an inclination to localize, and not to take the River St. Lawrence in its entirety, but to attribute all reasons to the local phenomena, without considering the rest of the River above and below the Harbour, and this is exemplified by the suggested parallel case of an embankment to Nun's Island under entirely different conditions.

The Report then returns to the actual scheme, and says the controlling sluices should be kept closed during the winter; so they should, as the mill sluices will pass sufficient water for all practical purposes, but by my Report to the Honorable the Minister of Public Works the Harbour Commissioners can open and shut them as they choose.

I must again correct Mr. Kennedy as to the nominal discharge of the mill sluices, which follow in his report, by stating; that my calculations are the *actual* discharge, the *effective*, but not the theoretical.

The Report then goes on to state the "contingency of an ice jam at the proposed bridge"—considering the history of Victoria Bridge this is very problematical. It then says in such case the sluices would have to be opened to relieve the river, and that it is more than probable they would be jammed by ice.

In my opinion this is not even probable, but it certainly is not *more* than probable, and taking the history of Victoria Bridge, an ice jam at our bridge is unlikely; and therefore the probability of the sluices being "useless when most required," to quote the report, is certainly more than improbable.

Mr. Kennedy then says that the current which I propose in the South Channel, or St. Lambert's Channel as he calls it, is 1½ miles less than that in St. Mary's, but he seems to have forgotten that the South Channel is over twice the width of St. Mary's. He then remarks upon the levees; these I have already explained, and they are approximately shown upon the plan.

Then comes the following:—"In fact, Mr. Bateman says that while the proposed works are expected to raise the water at Laprairie only 4½ feet, the lowest land is some 11 feet above present water, and it is therefore impossible that it would be flooded." This quotation from me is incorrect, as I state the following (see page 3 of my report):—"With regard to the low lying lands between Laprairie and Victoria Bridge, the result of the investigations that I have made, is that the proposed alterations would only create a rise of the water at Victoria Bridge of about 4 feet 6 inches, and as the lowest land in the neighbourhood of Laprairie is some 11 feet above the level of the water at this point, it is impossible that the jamming of ice in the lower portion of the St. Lawrence, having raised the water above Victoria Bridge to the height that it generally does at these times, should alter the height of water at Laprairie and the adjoining lands themselves."

From the above two quotations it will be seen that I do not propose to raise the water at Laprairie 4 feet 6 inches, but only at Victoria Bridge, and by looking at the plans attached to my report, that I state "the levels will be slightly lower than shown here," and that I do not say it is impossible our works would flood Laprairie, only that they would not do so more than now.

The remaining portion of the report it seems to me unnecessary to touch upon, further than to state that in the extensions to the scheme I propose a canal from Brassey's Wharf into the Lachine Canal Basin, and should it be necessary, a tunnel under the Lachine Canal to connect with any railway lines the future Company may wish to connect with.

Taking, however, into consideration my statement before the Harbour Board with regard to the wharfage which Mr. Kennedy mentions in the last paragraph of his report, his last incorrect quotation from my report, and the different errors which I think I have been able to point out to you, I think I may, gentlemen, strongly recommend you to proceed with your scheme, and endeavour to obtain a charter from the Dominion Parliament.

I have the honour to be,

Gentlemen,

Your obedient servant,

F. FOSTER BATEMAN,

M. Inst. C. E.

(Ap. 1.)

JANUARY 2ND, 1882.

THE SOUTH CHANNEL OF THE ST. LAWRENCE.

Shewing approximately the depth, areas, etc., of the river.

Schedule No.	Condition of river.	Breadth of river.	Depth of river.	Area of river.	Wetted Perimeter of river.	Total fall of river.	Distance over which fall extends in river.	REMARKS.
		Lin. feet.	Ft. inc.	Sq. feet.	Lin. feet.	Ft. inc.	2¾ miles.	
A	Low water	2952	10.6	31723	3247	8.6	do	
B	Rise of 2'.6"	2981	13.0	38739	3292	6.0	do	
C	do 5.0	3010	15.6	45827	3337	4.3	do	
D	do 7.6	3039	18.0	52988	3382	4.3	do	
E	do 10.0	3058	20.6	60222	3427	4.3	do	

(Ap. 1 v.)

VELOCITIES AND DISCHARGE OF SOUTH CHANNEL.

Schedule No.	Condition of river.	Hydraulic mean. Depth of river.	Fall in feet per mile.	Velocity in feet per minute.	Velocity in feet per hour.	Discharge in cubic feet per hour.	REMARKS.
A	Low water.	9.80	3.00	423.50	25,410	806,081,438	
B	Rise of 2'.6"	11.80	2.25	401.50	24,090	933.222,510	
C	do 5.0	13.70	1.50	352.00	21,120	967,866,240	
D	do 7.6	15.60	1.50	376.75	22,605	1,197,793,740	
E	do 10.0	17.55	1.50	396.00	23,760	1,433,094,720	

(Ap. 2.)

January 2nd 1882.

St. Lawrence Bridge and Manufacturing Scheme.

ST. MARY'S CURRENT.

Shewing areas depths, &c., approximately of the Channel.

Schedule No.	Condition of River.	Breadth of River.	Average depth of River.	Area of River.	Wetted Perimeter of River.	Total fall of River.	Distance over which fall extends in River.	REMARKS.
		Feet.	Ft. in.	Square feet.	Ft. in.	Ft. in. Ft. in.		
A 1	Low water.	1380	27	33910	1420	6 6 to 7	2¾ miles.	
B 1	Rise of ft. in. 2 6	1400	29 6	37410	1442 6	4 " 4 6	" "	
C 1	" 5 0	1420	32	40960	1465	3	" "	
D 1	" 7 6	1440	34 6	44560	1487 6	2 9	" "	
E 1	" 10 0	1460	37	48210	1510	2 9	" "	
F 1	" 12 6	1480	39 6	51910	1532 6	2 9	" "	
G 1	" 15 0	1500	42	55660	1555	2 9	" "	

VELOCITIES AND DISCHARGE OF ST. MARY'S CURRENT.

Schedule No.	Condition of River.	Hydraulic mean. Depth of River.	Fall in feet per mile of River.	Velocity in feet per minute.	Velocity in feet per hour.	Discharge in cubic feet per hour.	REMARKS.
A 1	Low water.	24′ 0″	2·45	594·0	35·640	1208·552·400	
B 1	Rise of 2′ 6″	26′ 0″	1·50	484·0	29·040	1086·386·500	
C 1	" 5′ 0″	28′ 0″	1·10	429·0	25·740	1054·310·400	
D 1	" 7′ 6″	30′ 0″	1·00	423·5	25·410	1132·269·600	
E 1	" 10′ 0″	32′ 0″	1·00	440·0	26·400	1272·744·000	
F 1	" 12′ 6″	33′ 6″	1·00	450·0	27·000	1401·570·000	
G 1	" 15′ 0″	36′ 0″	1·00	467·5	28·050	1461·263·000	

(Ap. 3.)
JANUARY 2ND, 1882.

THE SOUTH CHANNEL,

Shewing approximately areas, &c., of water-ways, ice jams, &c., under certain conditions of the River St Lawrence.

ST. LAWRENCE BRIDGE AND MANUFACTURING COMPANY.

Schedule No.	Condition of the River.	Depth of the dam of ice.	Mean depth of *water* before the ice dam took place.	Mean depth of *water* after the ice dam took place.	Breadth of the floating surface for ice before the ice dam took.	Breadth of the floating surface for ice after the ice dam took.	Area of the ice dam.	Area of the water-way for ice and water before the ice dam tock place.	Area of the water-way for ice and water after the ice dam took place.
		Ft. in.	Ft. in.	Ft. in.	Feet.	Feet.	Sq. feet.	Sq. feet.	Sq. feet.
A	Low water.	2.6	10.6	8.0	2,952	2,824	7,115	31,723	24,608
"	" "	7.6	" "	7.6	"	2,784	21,045	"	10,673
"	" "	10.0	" "	0.6	"	700	26,555	"	4,168
With 2 ft. 6 in. Rise in River.									
B	Rise, 2ft. 6in.	10.0	12.6	3.0	2,981	2,784	27,910	38,739	10,829
With 10 ft. Rise in River.									
E	Rise, 10ft.	10.0	20.6	10.6	3,058	2,952	28,499	60,222	31,723

(Ap. 4.)

January 2nd, 1882.

St. Lawrence Bridge and Manufacturing Company.

ST. MARY'S CURRENT,

Shewing approximate areas, &c., of water-ways, ice jams, &c., under certain conditions of the River St. Lawrence.

Schedule No.	Condition of the River.	Depth of ice dam.	Mean depth of water before ice dam took.	Mean depth of water after ice dam took.	Breadth of floating surface for ice before ice dam took.	Breadth of floating surface for ice after ice dam took.	Area of ice dam.	Area of water-way before ice dam.	Area of water-way after ice dam.	REMARKS.
		Ft. in.	Ft. in.	Ft. in.	Feet.	Feet.	Sq. feet.	Sq. feet.	Sq. feet.	
A 1	Low water.	5.0	27.0	22.0	1,380	1,330	6,750	33,910	27,160	
"	" "	17.0	"	10.0	"	1.120	21,890	"	12,020	Nearly the same as ice dam South Channel of 7 ft 6 in. only.
"	" "	23.3	"	3.9	"	554	28,765	"	5,145	Nearly the same as ice dam South Channel of 10 ft. only.

Rise in River of 2 ft. 6 in.

Schedule No.	Condition of the River.	Depth of ice dam.	Mean depth of water before ice dam took.	Mean depth of water after ice dam took.	Breadth of floating surface for ice before ice dam took.	Breadth of floating surface for ice after ice dam took.	Area of ice dam.	Area of water-way before ice dam.	Area of water-way after ice dam.	REMARKS.
B 1	Rise, 2ft. 6in.	23.3	29.6	6.3	1,400	1 120	28,805	37,410	8,605	Less than the same rise in S. Channel by one-fifth would give.

Rise in River of 10 ft.

Schedule No.	Condition of the River.	Depth of ice dam.	Mean depth of water before ice dam took.	Mean depth of water after ice dam took.	Breadth of floating surface for ice before ice dam took.	Breadth of floating surface for ice after ice dam took.	Area of ice dam.	Area of water-way before ice dam.	Area of water-way after ice dam.	REMARKS.
E 1	Rise, 10ft.	23.3	37.6	14.3	1,420	1,330	28,895	48,210	19,315	The South Chan-gives nearly the double of this.